# ON CERTAIN ENTOMOGENOUS FUNGI

A. T. Speare

(With Plates 3–5)

## I

### The Genus Hirsutella of Patouillard

While it is customary to think of the entomogenous fungi as members for the most part of the groups Entomophthorales, Ascomycetes and Fungi Imperfecti, there are in literature several records in which such a habit has been attributed to certain Basidiomycetes. Among the latter may be mentioned the various species of *Septobasidium* and the form called *Hirsutella entomophila* by Patouillard.

The present paper deals with certain fungi that are evidently closely related to the latter. It will be shown, however, that they should not be considered as Basidiomycetes, but rather that they should be looked upon as constituting a rather definite form genus of the Fungi Imperfecti, with which group they must apparently be associated until the perfect stages are found.

The paper by Patouillard (1892) in which *Hirsutella entomophila* is described, although without illustrations, is otherwise quite comprehensive, and there is little doubt in the opinion of the writer that the fungus mentioned is closely allied to members of the group herein considered, and in fact it is looked upon as identical with one of them.

The description of *Hirsutella entomophila* may be quoted in order that it may be readily compared with those of the other species noted below.

"Hirsutella Pat. nov. gen. Hymenomycétes, homobasidiés, en forme de clavaires, simples ou rameux, dressés, rigides, presque coriaces. Hymenium amphigène, disjoint; basides sessile ou presque sessiles; sous-hymenium nul; stérigmates 1–2, subulés, très allongés. Spores incolores.

"*Hirsutella entomophila* Pat. nov. spec. ————. Sur coléoptère adulte; Pallatanga, Equateur, Septembre 1891.

"*Mycelium* émergent du corps de l'insecte sous forme de filaments grêles (2–3 microns) entrelacés en un tomentum gris-cendré. Clavules nombreuses, petites (3–5 mm., de haut), grêles, rigides, simples, cylindracées, aigues et sterile au sommet, d'un gris-violace, blanchâtres a l'extrémité. Basides sessiles ou subsessiles ovoides (8–10 × 5–6 microns); stérigmate unique, subulè, trés allongé, un peu renflé a sa partie infèrieure et mesurant 30–45 microns de longueur. Spores hyalines, citriformes, 8 by 6 microns, apiculées aux deux extrémités."

In comparing *Hirsutella* with other members of the lower Clavariaceae, Patouillard observed certain characters of the former such as, for example, the extraordinary length of the sterigmata, the lack of a definite continuous hymenium, the coriaceous consistency of the "clavules," and the complete absence of a subhymenium, that were not shared by any genera of the true Clavariaceae, and suggested because of such differences that a new genus (*Hirsutella*) be formed to receive his anomalous species. In reality the characters noted above are of such a nature that it is difficult to understand why the fungus should have been considered as a Basidiomycete at all. In dealing with the species as a member of this family, however, Patouillard looked upon the inflated base of the sporophore as the basidium, and considered the attenuated distal portion of the same organ as the sterigma, noting that only one of the latter was borne on each basidium. The true nature of the "basidiospores" was apparently not observed for they were described as "citriforme" in shape, whereas, careful microscopic studies of stained and unstained spores by the writer have shown that they are in reality fusiform in outline, although mucus is deposited about the spores in such a way as to render them uniformly lemon-shaped.

In addition to the paper mentioned above, there are in literature several references to fungi of this type which should be mentioned in this connection. Ditmar (1817) described as *Isaria sphaecophila* a fungus occurring on a hornet which shows a certain resemblance to forms herein considered. The illustrations furthermore suggest such a relationship. The spores were said to be globose and hyaline and were entangled among short, rigid hairs which arose at right angles to the synnemata.

Cooke (1892) described as *Isaria saussurei* pro. tem. another hornet parasite. The fungus was originally figured only by

Saussure (1853) but the illustration was later copied by Gray (1858) and still later by Cooke, the latter venturing to give it the name mentioned above. In general appearance it bears a close resemblance to a form on *Polistes* that was brought to the attention of the writer in Hawaii, which is closely allied to *Hirsutella entomophila,* and although no microscopic characters of *I. saussurei* were ever recorded, there seems to be no good reason for considering it different from the Hawaiian and other forms mentioned below.

The writer (1912) considered under the name "Sterile Cordyceps" a fungus that was found upon specimens of *Perkinsiella saccharicida* in Hawaii, and at that time being unfamiliar with Patouillard's paper did not suspect the now evident relationship of this form with *Hirsutella entomophila.*

The description and figures by Vosseler (1902) of *Isaria surinamensis* sp. nov. and *Isaria gracilis* sp. nov., two species occurring on *Amphonyx cluentus* and *Anthophora zonata* respectively, clearly show a resemblance to the fungi herein considered. In gross appearance, in the microscopic structure of the synnemata, both of these forms show characters in common with those of *Hirsutella,* and while the sporophores appear at first sight somewhat different from the analogous organs of *Hirsutella,* it should be noted that in old specimens of the latter only the basal portions of the sporophores persist and that the attenuated terminal portions are somewhat delicate and disappear after the spores are formed. Furthermore, in many instances development of the sporophores seems oftentimes to be arrested so that only the stump like inflated basal portions are formed. In such cases a condition, Plate 3, Fig. 6, is brought about that is quite like that illustrated by Vosseler on his Plate VIII, Figs. 3 and 9.

Vosseler has not made clear either by figures or by text, however, the nature and method of formation of the bodies which he calls the spores. His illustrations of these bodies show no resemblance to the spores of *Hirsutella,* and on account of the fact that he was unable to show how they were formed, it is evident that he possessed old specimens in which the true fruiting stage had disappeared, and that the spores which he described should probably not be associated with the fungi mentioned.

There is little doubt therefore in the opinion of the writer that *Isaria surinamensis* Voss. and *I. gracilis* Voss. (not *Isaria gracilis* Speg.), should be associated with the forms herein considered, but whether or not they are identical with any of the species described below cannot be determined from the data at hand.

Thaxter (1891) described an interesting fungus, *Desmidiospora myrmecophila,* which was found on an ant in Connecticut. While its resting spores are anomolous in character, and although no structures analogous to the synnemata of *Hirsutella* were described, its subulate sporophores and fusoid spores are of the same type as the corresponding organs of the forms under consideration.

In this connection, it should be noted that von Höhnel (1909) agrees with the writer in concluding that fungi of this type should be removed from the genus *Isaria.* He proposed, however, a new genus of Hyphomycetes, *Phaeoisaria,* to include among other things *Isaria surinamensis* Voss., *I. gracilis* Voss. and *I. sphaecophila* Ditm., but it is evident that if any name other than *Isaria* is to be used for fungi of this type it must be *Hirsutella.*

The published information on the subject and the specimens at hand show that such fungi are found upon members of all of the larger insect orders except the Diptera, and Dr. Roland Thaxter, of Harvard University, has informed the writer that he has in his herbarium similar fungi on flies. The hosts, so far as known at the present time, may be noted in detail in the following table.

A glance at this table will show at once that of the specimens at hand the greater part have come from tropical or subtropical regions, and also that the greater number of hosts are found among the Hemiptera, the family Fulgoridae being particularly conspicuous. Furthermore, it will be noted that two of the hemipterous hosts—*Peregrinus maidis* and *Perkinsiella saccharicida*—are pests of considerable economic importance in the localities mentioned.

The illustrations on Plate 3 show the general character of the fruiting stalks or synnemata, which in all of the species but one,

herein considered, are of the same general nature. To the naked eye the synnemata appear as long, simple or branched, often spirally twisted, *Isaria*-like stalks, which at maturity are brownish in color or sometimes almost black. They are more or less rigid in all of the species and retain their form in old preserved specimens. A dozen or more may occur on one host, Plate 5, Figs. 1, 3 and 4, and while in certain cases they appear to arise from a cottony external subiculum, in other instances it is evident that they emerge directly from the body of the host. In the form on *Peregrinus* however, the synnemata do not assume the stilbaceous habit characteristic of the other species, being in this instance little more than papillate or verruciform outgrowths seated upon a noticeably conspicuous external subiculum of hyphae which is itself sporiferous.

| | Host | Host determined by | Collected by | Locality |
|---|---|---|---|---|
| Hemiptera. | Fulgoridae. | E. H. Gibson. | O. H. Swezey. | Auckland, N. Z. |
| | Fulgoridae. | E. H. Gibson. | J. H. Stevenson. | Rio Piedras, P. R. |
| | *Ricania discalis* Walk. | E. H. Gibson. | O. H. Swezey. | Auckland, N. Z. |
| | *Siphanta acuta.* | O. H. Swezey. | O. H. Swezey, A. T. Speare. | Hawaii. |
| | *Peregrinus maidis* | A. H. Ritchie. | A. H. Ritchie. | Jamaica. |
| | *Perkinsiella saccharicida.* | ? | F. W. Terry. | Hawaii. |
| Hymenoptera. | *Polistes annularis.* | S. A. Rohwer. | R. W. Leiby. | Raleigh, N. C. |
| | Wasp. | | C. V. Riley? | California. |
| | " | | ? | West Virginia. |
| | *Polistes* sp. | | M. Newell. | Hawaii. |
| | " | ? | (Ditmar) | Germany. |
| | " | | ?(*I. sphaecophila*). Saussure (*I. saussurei*). | |
| | *Anthophora zonata.* | ? | Gedé | Java. |
| | Wasp. | | ?(*I. gracilis*). Hohnel ?(*I. gracilis*). | " |
| Coleoptera. | *Diabrotica* sp. | W. S. Fisher. | H. Morrison. | Trinidad, B. W. I. |
| | Chrysomelidae. | ? | Lagerheim. | South America. |
| Orthoptera. | Cricket. | | A. T. Speare. | Hawaii. |
| Lepidoptera. | *Amphonyx cluentus.* | ? | Epp. ?(*I. surinamensis*). | Surinam. |

In all of the species the synnemata are composed of numerous somewhat interwoven but nearly parallel septate hyphae that

adhere to one another tenaciously. The character of the fruiting stalk is illustrated on Plate 3, Fig. 1. Certain of the hyphae which lie near the surface of the stalk produce short, usually sessile subulate sporophores and while there is some variation in the shape of these bodies in the different species, they invariably have swollen or inflated basal portions which in all of the forms are surmounted by single extremely long, attenuated sterigmata. It should be noted, however, that many specimens, particularly old ones, do not show such a richly developed sporiferous condition as that illustrated, because development of the sporophores seems to cease in many instances when the inflated basal portions only are formed. Furthermore, after spore formation, the sterigmata often collapse, leaving the swollen basal portions however, in situ, rendering a condition quite comparable to that figured and described by Vosseler for *Isaria surinamensis*.

The spores which are borne singly at the tips of the sterigmata vary from fusoid to allantoid to cylindrical in the different species and are also somewhat variable in size. In all cases a gelatinous substance surrounds them which if carelessly examined might be considered as a part of the spores. That this substance is a secondary product can be determined by examining regions of the synnemata where the spores are being formed. In such positions the newly formed spores are naked and definitely of the fusiform type. Furthermore, if the spores on adjacent sporophores come in contact with one another their matrices coalesce in a manner such as that illustrated on Plate 3, Fig. 16, demonstrating that no cell wall is present.

In all cases the parasitized hosts are fixed to the substrata by undifferentiated rhizoidal hyphae.

As noted in the paper cited above (Speare 1912) it is probable that these forms are the imperfect stages of one or more species of *Cordyceps* or related genera. Actually, however, such a relationship has not been proven in a single instance either by pure culture, continuity of development, association in the same stroma, or other means. Furthermore, while the writer has collected and examined hundreds of specimens of the species which occurs in epidemic form on *Siphanta acuta* in Hawaii, no perfect

stage has been observed, and although specimens of the other parasitized hosts at hand are much more limited in number, an acigerous stage has not been observed in connection with any of them. While therefore it is probably true that these forms are the imperfect stages of *Cordyceps* or an allied type, the condition that is likely to be met with in the future is that mentioned above. This is deemed by the writer as sufficient reason for describing the following imperfect stages, and although recognizing their probable relation to *Cordyceps* it seems advisable for the present to retain the name *Hirsutella* for the genus, members of which are unlike any other described entomogenous forms known to the writer, although in accepting this name care should be taken not to associate it with the Basidiomycetes, with which it evidently is in no way connected. The genus *Hirsutella* should be looked upon in the same manner as is *Gibellula* and other genera that have been removed from the composite genus *Isaria,* and in accordance with this conception the following description may be given.

### HIRSUTELLA Pat.

Fruiting bodies in the form of simple or branched, long, erect, slender and rigid, or short verruciform synnemata composed of more or less parallel septate hyphae. Sporophores simple, sessile or subsessile, subulate, the distal portion extremely long and attenuated and sharply set off from the swollen or inflated basal portion. Spores adjointed singly from the tips of the sporophores, fusoid, allantoid or cylindrical in form, hyaline, one-celled, their true shape obscured by a gelatinous substance which surrounds and renders them citriform in appearance.

The specimens in the writer's possession are clearly separable into five species, which are distinguished from one another largely on the characters of the spores and sporophores.

#### 1. HIRSUTELLA ENTOMOPHILA Pat.

Entomogenous. Synnemata arising directly from the body of the host 5–15 mm. long, much branched, rigid, often spirally twisted, brownish in color, sometimes fasciculate with their bases coalescing. Sporophores simple, sessile, the basal portion inflated but short, tapering gradually into relatively short (25–35 microns) sterigmata. Spores fusiform, $7.5 \times 1.5$ microns, hyaline, imbedded in gelatinous matrices.

Host: *Diabrotica* sp. (adult) Trinidad.

The above description is based upon a specimen from Trinidad, British West Indies, which is believed to be identical with the form described by Patouillard. The measurements of the spores (8 × 6 microns) as given by this author, apparently included the gelatinous substance surrounding the spores.

2. HIRSUTELLA SAUSSUREI (Cooke) comb. nov.

*Isaria saussurei* Cooke, pro. tem.

*?Isaria gracilis* Vos.

Entomogenous. Synnemata arising directly from the body of the host, usually very long (20–30 mm.), flexible, somewhat branched, more or less erect, brownish in color. Sporophores simple, sessile, the basal portion inflated, short, tapering rather abruptly to the usually very long (35–70 microns), slender sterigmata. Spores allantoid, 9–11 × 1–1.5 microns, hyaline, imbedded in gelatinous matrices.

Hosts: *Polistes annularis* (adult), North Carolina.

*Polistes* sp. (adult), Hawaii.

*Polistes* sp. (adult), California.

*Polistes* sp. (adult), British West Indies.

This species is readily distinguished from the others herein described by its long, narrow, and usually allantoid spores, as well as by its extremely slender sterigmata that are but slightly swollen at the base. *I. gracilis* Voss. has been included as a possible synonym but as the description of this fungus includes no discussion of the spores or other microscopic characters it is impossible to treat it more satisfactorily.

3. **Hirsutella floccosa** sp. nov.

Entomogenous. Synnemata short, verruciform, white, arising from a cottony subiculum. Sporophores simple, sessile, extremely robust, the swollen basal portion tapering very gradually into the short, rather stumpy sterigmata (10–15 microns); spores fusoid, hyaline, 9–10 × 3.2–3.8 microns.

Host: *Peregrinus maidis,* Jamaica, B. W. I.

This species is somewhat unlike those described above, in that the synnemata are merely wart-like outgrowths arising from an

external cotton-like subiculum. The spores and sporophores are also larger and more robust than similar bodies of the other species.

It should be mentioned that the characters of the spores and sporophores bear a certain resemblance to the analgous structures of *Acremonium danysz* Wize (1904), a parasite of *Cleonus punctiventris* in Russia.

### 4. **Hirsutella citriformis** sp. nov.

Entomogenous. Synnemata usually long, flexible, arising sometimes from a subiculum, sometimes directly from the body of the host, brown in color, simple or branched. Branches often short and stumpy, and easily detached. Sporophores simple, sessile or subsessile, with rather short, delicate sterigmata (20–30 microns). Spores fusoid, hyaline, 5.5–8.5 × 1.5–1.8 microns in size, imbedded in gelatinous matrices.

Hosts: Fulgoridae (adult), New Zealand.
Fulgoridae (adult), Porto Rico.
*Ricania discalis,* New Zealand.
*Perkinsiella saccharicida,* Hawaii.
*Siphanta acuta,* Hawaii.

### 5. **Hirsutella fusiformis** sp. nov.

Entomogenous. Synnemata erect, straight, unbranched, uniform in height, measuring 4–5 mm., nearly black in color, arising from the leg joints and sutures of the host's body, singly. Sporophores simple, sessile, the inflated basal portion tapering gradually to rather short (25–35 microns) sterigmata. Spores fusoid-cylindrical, measuring 9–10 × 2 microns in size, hyaline, imbedded in gelatinous matrices.

Host: Cricket (adult), Hawaii.

It is quite impossible from the data at hand to determine whether or not *Isaria surinamensis* Voss. is identical with any of the above species. In the writer's opinion, however, it undoubtedly is closely related to them and should therefore be placed in the genus *Hirsutella,* and if distinct it should be called *H. surinamensis* (Voss). In a similar manner it is difficult to ascertain the true nature of *Isaria sphaecophila* Ditm., and though

probably this species belongs with the fungi mentioned above, it should perhaps be regarded as a distinct form on account of the knob-like processes which occur upon the synnemata.

## II

### **Synnematium Jonesii** gen. et sp. nov.

This fungus was found upon specimens of *Mezira emarginata* Say. and *M. lobata* Say.,* which were sent to the writer by T. H. Jones of Baton Rouge, La.

Although a large number of the insects showed the *Isaria*-like synnemata which characterize the fruiting stage of the organism, other specimens, although dead, showed no external signs of fungus parasitism. The latter were placed in a moist chamber and in a few weeks fruiting bodies of the fungus, Plate 5, Fig. 5, appeared on all but one or two of the individuals.

Artificial cultures on potato agar were readily obtained from the fresh viable material, and at the present time the organism is growing vigorously, although it has been sub-cultured several times since the original isolation in March, 1919.

The fruiting bodies of this form, like those of *Hirsutella,* consist of erect, stilbaceous fascicles of cohering hyphae. When young, Plate 5, Fig. 5, the fascicles are white and the hyphae of which they are composed are loosely coherent, presenting a flocculent appearance such as that illustrated. Later in their development, however, the synnemata are brown in color, and the hyphal elements are more closely associated so that a fully developed fruiting body appears to the naked eye quite like that of *Hirsutella* or like the fruiting stalk of many species of *Cordyceps.*

The structure of the stalk is illustrated on Plate 4, Fig. 1. The sporophores which are produced at the sides and at the tips of the synnemata are long and slender, tapering gradually and uniformly from the base to the tip, in this respect being unlike the homologous organs of *Hirsutella.* Those at the tip of the synnemata, while clearly differentiated from the elements of the

* Determined by Prof. H. M. Parshley through the courtesy of Mr. E. H. Gibson.

stalk, remain closely applied to one another and definitely terminate the growth of the fruiting body. Those at the sides of the synnemata usually occur singly. The spores are abjointed successively from the tips of the sporophores and become incorporated in a mucus like substance that is secreted copiously during the process of spore formation, Plate 4, Fig. 1, in such a way that globular spore masses are produced. The largest of these which are formed at the tips of the synnemata where the sporophores are grouped together are easily observed with the naked eye, and appear at first like the deliquescent, translucent sporangia of certain mucors. Later they become brown or almost black.

In addition to the spores, which are thin-walled and evidently formed for the purpose of infecting other insect hosts when favorable conditions obtain, a second type of reproductive body is produced, the object of which is apparently to tide the fungus over unfavorable conditions. These bodies, the sclerotia, are formed at the tips of certain branches of the synnemata in the manner illustrated on Plate 4, Fig. 3. The method by which they are produced has not been studied in detail, but such observations as have been made indicate that certain of the distal hyphae of the synnemata become twisted, knotted and intertwined about each other in such a way that spherical masses are produced, which after further development assume the appearance of typical sclerotia. These bodies usually appear after spore formation has reached its maximum, or even ceased, and in many instances entire synnemata become involved in their formation so that old tube cultures often contain only the sclerotia, which are formed in large numbers and easily become detached from one another and roll about the tube. At maturity they are brownish in color and roughly spherical, Plate 4, Fig. 6. When crushed, the elements of which they are composed separate from one another readily, and it will be observed that they are very thick-walled, Plate 4, Fig. 7, 9, and irregular in outline. When placed in sterile water, germination may take place at once, although it is obvious that because of their thick walls they are primarily intended to function as resting spores. In germinating,

the cell-wall apparently becomes in part absorbed by the protoplasmic contents of the cell, or at least becomes very much thinner, and a germ tube is pushed out, in the manner illustrated on Plate 4, Figs. 8 and 15, upon the tip of which a thin-walled spore of the type described above is cut off. The sclerotia when placed in a moist chamber produce fascicular hyphal outgrowths as shown on Plate 4, Fig. 5, which produce sporophores, and upon the latter thin-walled spores are abjointed that in every respect are similar to those described above.

The characters of this fungus as outlined above are of such a nature that in the opinion of the writer it cannot be associated with any other known genus of the Hyphomycetes. It is obviously of the stilboid type but the sporophores are borne upon the synnemata acropleurogenously and the spores are abjoined successively becoming incorporated in globular mucous masses, conditions that do not occur in association in any other form known to the writer.

In some respects it is not unlike members of the genus *Stilbum,* some species of which, such as *S. buquetii, S. kervillei, S. coccophilum,* etc., have furthermore been considered as entomogenous, but as the sporophores in the form under consideration are borne pleurogenously as well as acrogenously, and are well differentiated from the elements of the synnemata, it cannot be associated with the other members of the genus *Stilbum.* On the other hand it bears a certain resemblance to *Hirsutella, Sorosporella,* and in a certain degree to *Gibellula.* The characters of *Hirsutella* have been considered in the preceding pages and a glance at Plate 3 will show at once the similarity and at the same time the difference that exists between it and *Synnematium.* In *Sorosporella,* as the writer and others have pointed out, resting spore masses are produced, which although formed within the body of the insect are nevertheless analogous to the sclerotia of *Synnematium,* and furthermore a stilbaceous condition has been observed in *Scrosporella* which is not at all unlike that which occurs in the form under consideration. In general, it may be said that the species of *Hirsutella, Sorosporella, Gibellula,* and *Synnematium* resemble one another in that the stilbaceous fruit-

ing body is common to all, and, furthermore, with the exception of *Gibellula* a conspicuous bottle-shaped or subulate sporophore is invariably present in some form or modification, while at the same time the fusiform type of spore is present in each instance. It is also to be noted that in all of the above-mentioned genera with the exception of *Gibellula,* a viscous substance is secreted apparently by the spores, which might aid them in attaching themselves to new hosts, which, although not formed abundantly in *Sorosporella,* is supposed to be present because the spores cohere to one another after they are cut off. In *Hirsutella,* in which the spores are abjointed singly, this substance assumes a rather definite form, rendering the spores falsely citriform in outline, whereas in *Synnematium* as has been pointed out, it is secreted copiously and the successively formed spores become incorporated in it, forming large glomerules.

The characters of *Synnematium* are, therefore, sufficiently different from other forms known to the writer to justify a new name and the following description is therefore given.

**Synnematium** gen. nov.

Entomogenous. Fruiting bodies in the form of erect, dendroid synnemata, arising directly from the body of the host, at first white, later brownish in color. Sporophores borne laterally and terminally on the synnemata, the lateral ones occurring singly, the terminal ones fasciculate, sessile, uniformly and gradually attenuated from base to apex. Spores fusiform, hyaline, one-celled, abjointed successively, cohering in glomerules of mucus at tips of sporophores.

**Synnematium Jonesii** sp. nov.

Synnemata 5–10 mm. high, 100–200 microns in diam. At first whitish, flocculent, later brown and almost coriaceous, much branched, often tree-like. Sporophores in part arising as lateral branches of the elements of the synnemata, in part forming the terminal growth of the fruiting stalk, in the first instance occurring singly, in the second being fasciculate; in both cases nonseptate and clearly differentiated from the synnemata. Sporophores 40 microns long, gradually attenuate upward from base, which is 3.4 microns in diameter. Spores fusiform, hyaline, one-celled, 8–10 by 4–5 microns, borne successively and cohering after

they are cut off in mucus glomerules. Sclerotia 125–200 microns in diameter, roughly spherical, at first white, later brown in color. Elements of sclerotia very irregular in form but roughly spherical, measuring 10–15 microns in diam. provided with very thick (4–6 microns) walls.

Hosts: *Mezira emarginata* Say, Louisiana, U. S. A.
*Mezira lobata* Say.

BUREAU OF ENTOMOLOGY,
UNITED STATES DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

## EXPLANATION OF PLATES

### PLATE 3

Figs. 1–5. *Hirsutella saussurei.* (1) Portion of end of a synnema. × 532. (2) Middle portion of synnema showing method of branching. × 92. (3) Sporophore with attached spore. × 1048. (4) Sporophore. × 1048. (5) Spores.

Figs. 6–9. *Hirsutella fusiformis.* (6) Portion of a synnema. × 568. (7–8) Spores. × 1048. (9) Sporophore.

Figs. 10–11. *Hirsutella floccosa.* (10) Spores. (11) Sporophores. × 1048.

Figs. 12–13. *Hirsutella entomophila.* (12) Sporophore. (13) Spores. × 1048.

Figs. 14–15. *Hirsutella citriformis.* (14) Sporophores and spores from *Ricania.* (15) Abnormal development from *Siphanta acuta.* × 1048.

Fig. 16. Spores of *H. saussurei, H. citriformis,* and *H. fusiformis* imbedded in a mucus-like substance. × 568.

### PLATE 4

*Synnematium Jonesii*

Fig. 1. Terminal portion of a synnema showing (*a*) isolated lateral sporophores, (*b*) massed terminal sporophores, (*c*) mucus glomerules of spores. × 92.

Fig. 2. Terminal portion of a synnema showing a secondary growth arising from beneath the spore mass of the primary growth. × 92.

Fig. 3. Fruiting stalk showing sclerotia in situ. × 50.

Fig. 4. Portion of a synnema with sporophore in situ. × 1048.

Fig. 5. Sclerotium germinating on agar plate culture. × 65.

Fig. 6. Sclerotia. × 92. Fig. 7, cells of sclerotia. × 568. Fig. 8, the same germinating. × 568. Fig. 9, cell of sclerotium. × 1048.

Figs. 10–11. Spore glomerules. × 1048 and × 568.

Fig. 12. Spores. × 1048.

Fig. 13. Spore germinating. × 1048.

Fig. 14. Cells of sclerotium germinating. × 400.

Fig. 15. Single cell of sclerotium germinating. × 1048.

PLATE 5

Fig. 1. *Hirsutella saussurei* (Cooke) on *Polistes annularis*. × ¾.

Fig. 2. *Synnematium jonesii* Speare on *Mezira emarginata*, showing sclerotia. × 4.5.

Fig. 3. *Hirsutella citriformis* Speare on *Siphanta acuta*. × 1.

Fig. 4. *Hirsutella entomophila* Pat. on *Diabrotica* sp. × 1.8.

Fig. 5. *Synnematium jonesii* Speare on *Mezira emarginata*, showing synnemata. × 3.

Fig. 6. *Synnematium jonesii* Speare. Colony of the fungus growing in artificial culture. × 2.5.

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